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OPEN METHOD FOR MEASURING FIRE DANGER IN HARDWOOD FORESTS

by

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INTRODUCTION

All the 275 fire danger stations in that portion of the hardwood forests of Eastern United States extending northeastward from the Southern mountains and Piedmont use the same method for measuring fire danger. Sometimes fire control administrators cannot find typical forest sites for all of the necessary fire danger station locations in these 22 states. For example, when the district ranger planned stations for the White Sulphur District on the Monongahela National Forest, the only full-time observer that could be located lived near Neola, West Virginia, in an inaccessible corner on the edge of the district. There typical forest conditions could not be found within a quarter-mile of the observer's house, so the station had to be set up in a fringe of woods instead of an actual forest. Furthermore, each contact between the observer and the dispatcher involved the cost of a toll call. Such difficulties of inaccessibility, poor communications, and improper sampling are common when stations are located in the forest, but by measuring fire danger in the open, they can usually be avoided.

Now we have found that fire danger stations, with some modifications, can be placed in open areas (fig. 1). Such open stations, in addition to eliminating many problems, also increase the value of fire danger ratings because the measurements made are more accurate, inasmuch as uniform artificial shade replaces the variable light conditions in a forest; the effect of different stand densities is eliminated; site conditions can be maintained without change; and the effect of topography is minimized. Also, sampling is improved and fewer open stations are required.

Even so, an immediate change-over to the open method is not recommended. Since the moving of the 275 danger stations from the forest to the open would require the advance approval of the sites by the fire danger inspector and the procurement of additional equipment, the job could not be done immediately because of limitations on the inspector's time and the expense. Accordingly, the open method was modified intentionally to make the results directly comparable with those from typical forest stations so that any combination of open and forest stations may now be used in the same network.

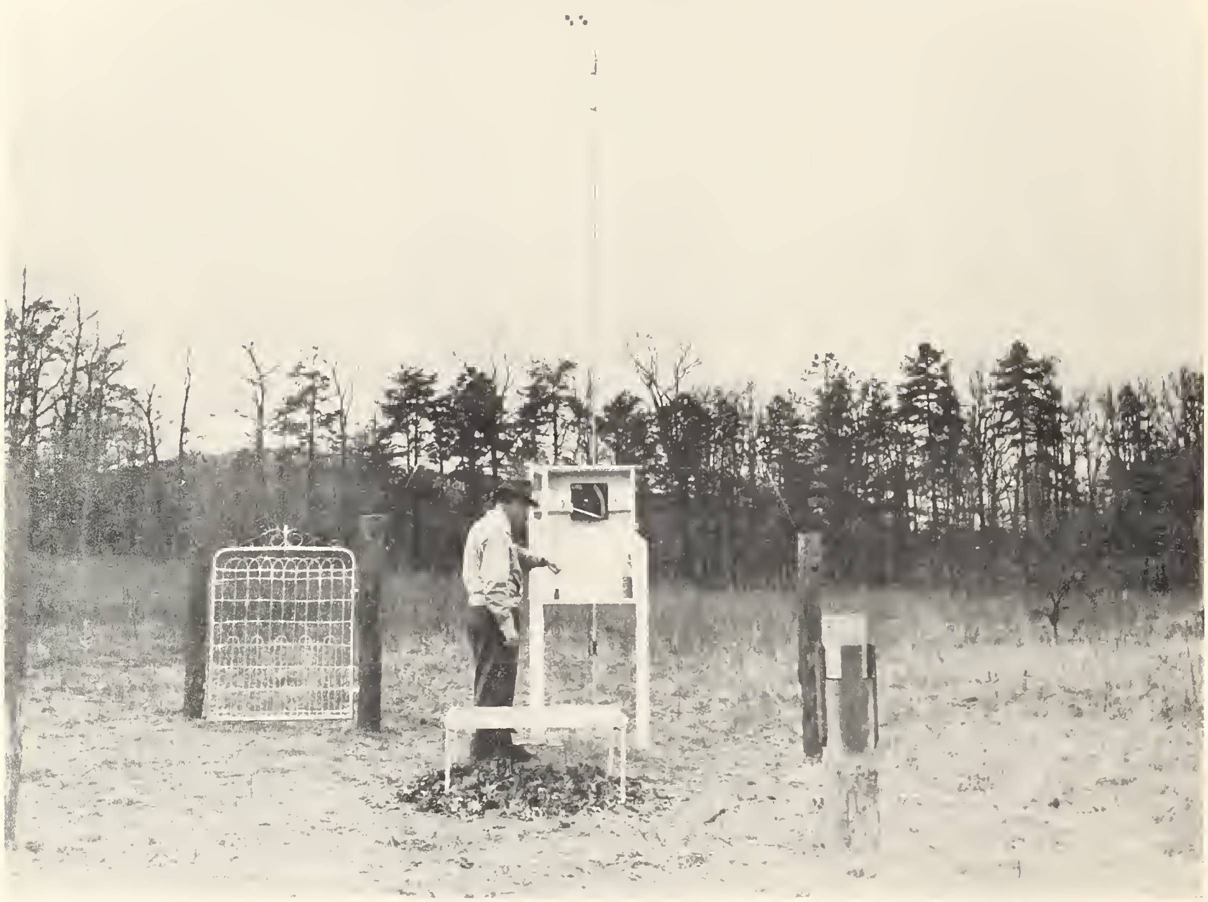

Figure 1.—Observer measuring wind velocity at an open type fire danger station.

This technical note outlines methods of setting up and operating an open fire danger station. No special mention is made of features which are not modified when stations are moved into the open, as the general guides in Technical Note No. 50, "The Measurement of Forest Fire Danger in the Eastern United States and Its Application in Fire Prevention and Control,"[1] still apply for danger station operation.

DEVELOPMENT OF METHODS

The standard forest fire danger station will not measure the same degree of fire danger when moved to open areas, unless some revisions are made. This is particularly true of the methods for determining fuel moisture and wind velocity. However, methods were perfected for measuring these factors so the readings are comparable with those taken within typical forest stands. The new methods have been tested and are accurate.

Fuel Moisture Determination

Since hardwood leaf cover exerts a powerful effect on fuel moisture, artificial shade is necessary in open stations to approximate the effect of forest leaf cover. The amount of artificial shade must vary too, as the amount of leaf cover varies in the forest. For example, in the forest during the period of full leaf the sunshine on clear days is ten times as intense in the open as in the forest. Likewise, the temperature in the open is higher and the relative humidity is lower, as one would expect. However, these differences in hardwood areas are not so pronounced during the season when the trees are leafless.

In order to compensate for these differences, varying types and degrees of artificial shade were tried. The measurements taken showed that conditions under one layer of either 14- or 16-mesh wire screen when hardwood trees are leafless, and six layers when hardwood trees are in full leaf, are practically the same as those in the forest.

Wind Velocity

The height for exposing the anemometer in the open has been set at 20 feet, which is the standard generally accepted by fire control

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1/ By George M. Jemison. Appalachian Forest Experiment Station, Asheville, N. C. 1942.

agencies in the United States. Therefore, the problem was to determine how the wind velocity at a height of 20 feet in the open compared with that measured 8 feet above the ground in an average forest. In order to find the answer, velocities were recorded for identical periods from anemometers mounted at standard heights on adjacent sites in the open and in the forest. From those readings the average ratio was calculated between the velocities measured in the forest and in the open. This determined gradations on the wind velocity disk of the new Type 5-0 Meter developed for use with open stations.

Field Test

The results from the preliminary fuel moisture and wind velocity studies were then tested at three stations set up in the open on Region 7 national forests on July 1, 1946. The test stations were located near regular forest stations in order that the measurements taken in the open could be compared directly with those made in the forest. As data accumulated, adjustments were made during the following year to improve the comparability between the open and forest stations.

After that test, the open stations were operated for six months without change in order to find out how their burning index, which is composed principally of fuel moisture and wind velocity, compared with that from the forest stations. Burning indexes, calculated on a scale of 100, were taken for a representative number of observations and added together with the following results.

Table 1.--Comparison of the burning index from forest and open stations

Season	Observations	Total burning index		Ratio	Average difference
		Forest	Open	Open/forest	
	Number	Units	Units	Percent	Units
Cured	73	1,036	1,027	99.43	0.12
Green	71	269	261	97.03	.11

The small average differences of 0.11 and 0.12 units of burning index, shown in table 1, will not materially affect organization planning or costs. Neither will annual summaries be affected, because when the burning index is weighted by the normal annual distribution of days and by season, the ratio between the data is 0.9923 to 1.0, or virtually the same.

HOW TO SET UP AND OPERATE AN OPEN STATION

Location of Station

Locate in broad valleys or flat country. These are the best places to measure the prevailing fire danger, whether measurements are made in the forest or in the open.

In the early days, sites near lookouts, which are usually on high mountains, were favored as locations for danger stations. However, experience has shown that often at these high elevations the station must be moved down the side of the mountain to find suitable forest conditions. But when that is done, the topography retards the wind movement from some directions and accelerates it from others, making measurements of velocity inaccurate. Furthermore, since the towers are only occupied part-time, the records at such locations are incomplete. It was for these reasons that the stations at Feathercamp, Fullhardt's Knob, and Mikes Knob towers on the Jefferson and Monongahela National Forests have been discontinued in the last two years. Also, Region 7 plans to discontinue 8 high-elevation stations and to move 5 others to lower locations as soon as possible. Many difficulties are avoided in broad valleys or flat country where the effect of topography on wind movement is practically eliminated and where the stations can be operated every day throughout the year by full-time observers. Furthermore, since most fires start in the valleys or on lower slopes, danger ratings obtained there are most meaningful.

Setting Up the Anemometer

When the general location for the station has been selected, the specific site for the anemometer should be located on a reasonably level open area. Exposed peaks, knolls, gaps, narrow valleys, sheltered spots, and obstructions should be avoided.

After the spot has been chosen, the exact height of the anemometer cups will be calculated as follows:

1. Estimate the average height of the ground cover; if vegetation is absent, use the average ground level. This is termed the surface correction.

2. Make an allowance for those obstructions that cannot be avoided in choosing the site. This is termed the obstruction correction.

3. Calculate the height for mounting the anemometer by adding the surface correction and the obstruction correction to the basic height of 20 feet.

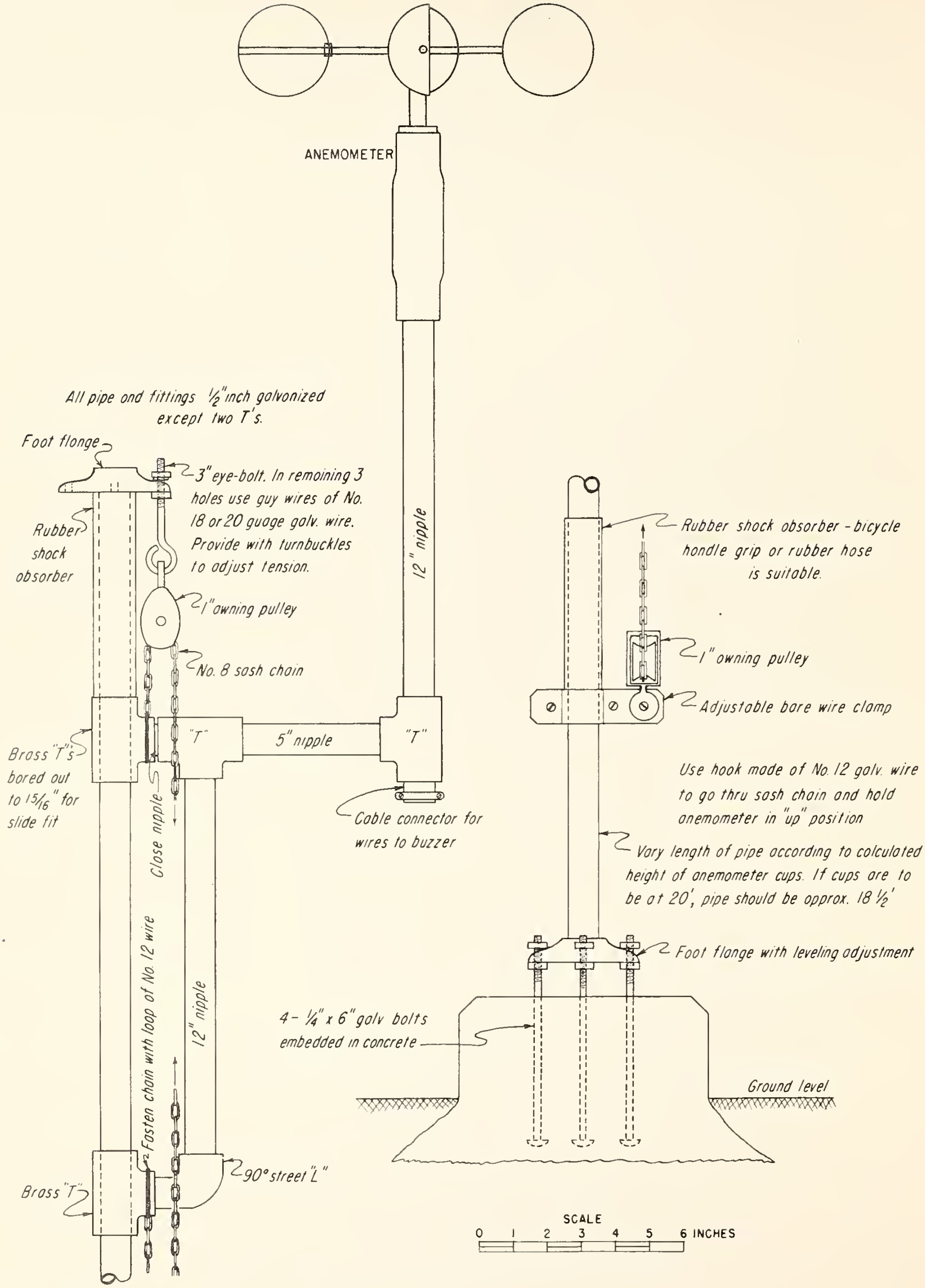

Figure 2.—A suggested anemometer mast and mounting. Instrument may readily be lowered, and is easily pulled up in position after servicing.

Formulae2/ for calculating anemometer height are as follows:

Anemometer distance from obstruction (Feet)	Correction for obstruction (Feet)	Total height of anemometer above ground 1/ (Feet)
2/ 0	3/ h	4/ h + z + 20
h	0.70h	0.70h + z + 20
2h	0.50h	0.50h + z + 20
3h	0.35h	0.35h + z + 20
4h	0.20h	0.20h + z + 20
5h	0.10h	0.10h + z + 20
6h	0.05h	0.05h + z + 20
7h	.0	z + 20

1/ Total height includes the 20-foot minimum, plus obstruction and surface corrections.

2/ If it is impossible to place the anemometer at a distance from an obstruction, place it above the obstruction.

3/ h = height of the obstruction. For buildings use the height of the ridge; for timber stands use the average height of the crown profile.

4/ z = average height of the ground cover.

Example: In a large abandoned pasture with a ground cover of brush averaging four feet in height and with five 20-foot apple trees 100 feet away, the anemometer height would be calculated by adding 4 feet (surface correction) and 2 feet (obstruction correction, 20 x 0.10) to 20 feet (basic height). That gives a total of 26 feet.

The height of the instrument, the type of materials available locally, and the fact that the instrument must be accessible for maintenance monthly, determine the style of the anemometer mast. A suggested style is diagrammed in figure 2.

Placing and Maintaining Fuel Moisture Sticks

When choosing the site for the fuel moisture sticks, handiness to the observer is the first consideration, and only sites that are intermittently shaded or are located near lakes, streams, or swamps need be avoided.

2/ Adapted from Fons, W. L., and Buck, C. C. Fire danger rating station standards. California Forest and Range Experiment Station. 1944. (Unpublished)

The sticks do not have to be close to the anemometer either, since the anemometer can be wired in to the buzzer or counter from any reasonable distance.

This handy site may be enclosed by a fence in order to protect the screens that shade the sticks. The woven wire enclosure should be approximately 16 feet square and 4 feet high so that its shadows will not reach the center where the square frame, 36 inches on a side, supports the screen wire over the sticks. A suitable ground plan arrangement is diagrammed in figure 3.

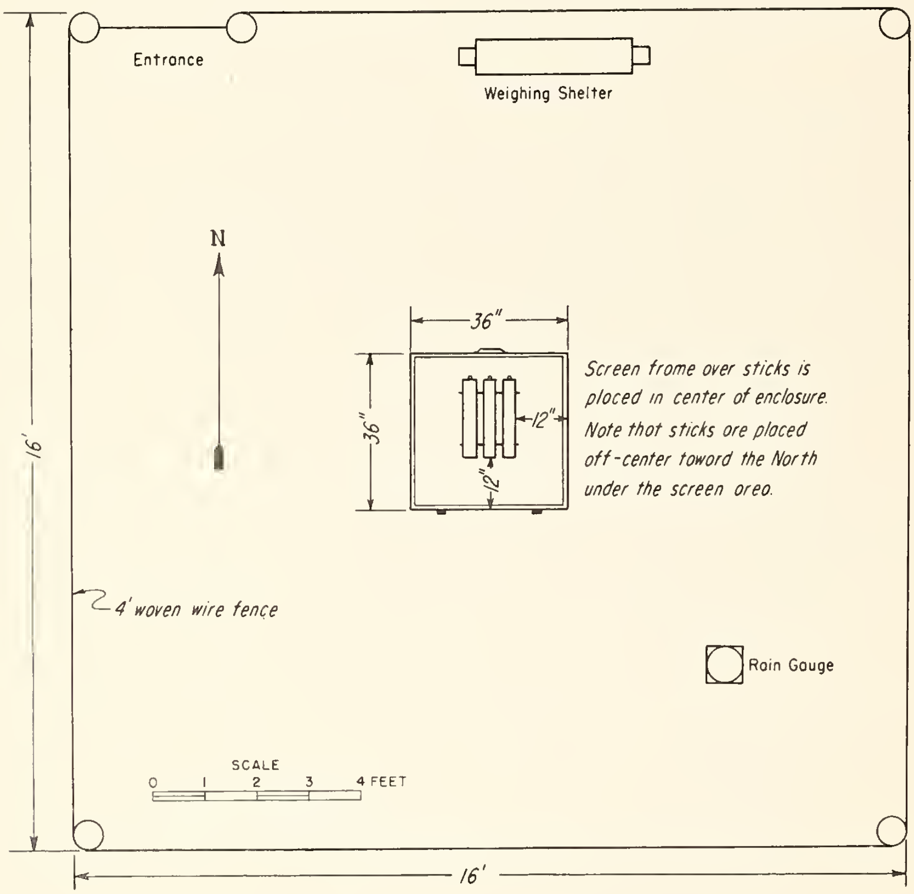

Figure 3.—Ground plan for open fire danger station. Install anemometer on north side of weighing shelter, outside the fenced area.

The number of layers of screen wire which control the amount of shade cast on the fuel moisture sticks is varied to correspond to the major changes by season in the density of the forest foliage. Details of fuel-moisture-stick installation are shown in figure 4. Two degrees of

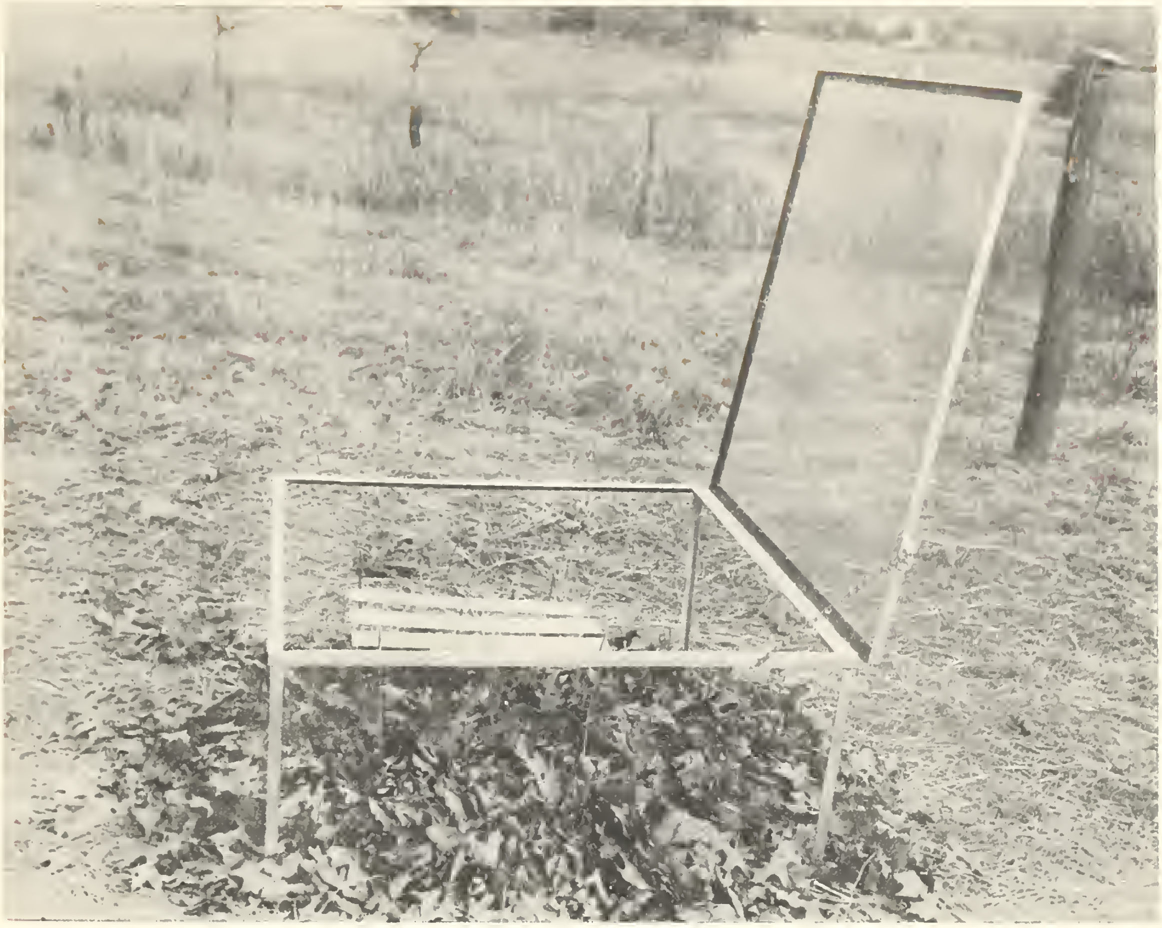

Figure 4.--A typical fuel moisture stick installation at an open fire danger station. Picture shows single screen frame used during the leafless period. By using loose-pin butt hinges the single screen frame may be quickly removed and the 6-layer frame installed.

Screen - 14- or 16-mesh copper or bronze, 36 inches square. Screen must be level and 16 inches from ground. Measure from center if ground slopes.

Screen frame - 3/4-inch angle iron, 36 inches square inside. Screen fastened to frame with 24 brass bolts spaced at 6-inch intervals. Two frames are needed, one holding a single screen and the other with 6 layers of screen.

Base - 3/4-inch angle iron, 35-3/4 inches square outside; legs 30 inches long, approximately 14 inches in ground.

Sticks - mounted on two wickets, each made of about 4 feet of No. 9 galvanized wire. A third straddle wicket should be used to hold sticks from blowing off. Sticks should be mounted level, 4 inches below screen and 8 inches above a prepared bed of litter. The litter bed should be 4 inches deep.

shading are used; one layer of 14- or 16-mesh rust-proof screen when the hardwood trees are leafless and six layers when the hardwood trees are in full leaf. In the spring when the leaves on the hardwood trees are half grown, the change is made from one layer to six layers. In the fall when half the hardwood leaves have fallen, the change is made from six layers to one layer. That estimate of foliage density should be made on a district basis and at the elevation where the risk of fire occurrence is greatest. The estimate refers only to foliage density and is not related to the condition of vegetation (see Technical Note No. 50). The two factors should be estimated independently, as they are used for entirely different purposes.

To simulate forest conditions further, a bed of hardwood leaves, the same as that in the forest, is maintained under the sticks to control the amount of light reflected. The bed should be 4 inches thick and 36 inches square, the same size as the frame of the screen. The litter is held in place by a layer of poultry wire, pegged down as needed.

The care used in maintaining the artificial shade influences the accuracy of the fuel moisture measurements. Accurate measurements require the prompt removal with a whisk broom or brush of any dirt or debris that collects on the screens; the restretching or replacing of screens when they become sagged or damaged; the current clipping of grass or weeds in and for a distance of approximately 6 feet surrounding the fuel bed; and the renewal of the litter bed semi-annually, spring and fall, before the fire seasons.

Rain Gauge and Weighing Shelter

While the anemometer and fuel moisture installations have been modified, no changes are being made in the manner in which the weighing shelter and the rain gauge are set up, except that at the open stations the gauge may usually be placed inside the fenced area.

Fire Danger Meter and Records

Even though the exposure of the anemometer and fuel moisture sticks has been changed, all the measurements are taken and recorded as instructed in Technical Note No. 50. Of course, as conditions in the open vary somewhat from those in the forest, a special meter is required to integrate the measurements made in the open and give a burning index representing forest conditions. This special meter, designated Type 5-0, is furnished to danger stations by the Southeastern Forest Experiment Station.

There is only one weather condition that is not fully covered in Technical Note No. 50. That is when snow blankets the ground in the forest. On such days the burning index is recorded as zero; there is no need to measure wind velocity or fuel moisture. Only the amount of precipitation, days since rain, and burning index are recorded. This special procedure is followed until the melting snow on the south slopes in the forest becomes patchy.

CONCLUSION

This report has dealt chiefly with the modifications and techniques necessary for measuring fire danger at stations in the open. Principles of fire danger measurement and specific instructions for making measurements and recording the data have been purposely omitted because they are covered in detail in Technical Note No. 50.

The open method that has been described is no longer in the experimental stage, as it is already being used on the George Washington National Forest. Additional open stations have been planned and will be set up as time permits in the next few years on other national forests.

In the plan for these changes, the regional network was carefully examined and an attempt was made to improve both the spacing and sampling. Only those forest stations that were difficult of access or had sites that were not typical are being moved to the open. It is not proposed that any forest stations be moved that are operating satisfactorily.

That same approach is suggested to any fire control administrator who is having difficulty either in locating new stations or in obtaining satisfactory records from established stations.